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MATERIALS, APPARATUS, AND PROCESSES OF THE ABORIGINAL LAPIDARY.

BY JOSEPH D. M'GUIRE.

In nearly every city of the world public collections of prehistoric archeology are found, and the number of private collections may be counted by thousands. If there is an intelligent purpose in these, it must be to enlighten students as to their fabrication and use.

Many of the names by which these objects are known are purely conventional and often misleading. Where the use of a given object is unknown a conventional name is of course all that is necessary. It is hardly possible for the careful observer to regard the implements of a forgotten race without speculating as to the uses to which they were devoted and wondering how a people in a stage of savagery or barbarism, with the rude tools available, could make objects of such beauty of finish and work with facility stones so obdurate that the modern workman with his appliances finds great difficulty in manipulating them. The shape of a given object or the material of which it is made is indicative of the grade of intelligence of a race. Archeologists have usually contented themselves with collecting specimens and drawing their own deductions from them ; but there are a few notable exceptions to this rule, among which Dr. Charles Rau's paper on "Drilling in Stone Without Metal" and W. H. Holmes' paper "On Stone Chipping" may be mentioned. The reproduction of aboriginal methods of work cannot fail to add to our knowledge, not only concerning the daily life of the aborigines but also as to the degree of intelligence possessed by their workers. The most superficial examination of any fairly large collection of stone implements is calculated to convince the observer that man in his lowest stage of development was well acquainted with the methods of fracture of various stones, and also that he was a most skillful workman. The articles found in burial places, in caves and shell-heaps, as well as surface finds, furnish conclusive evidence that man often carried material many hundreds of miles for the purpose of fashioning at his leisure objects of personal adornment or domestic utility as well as weapons.

If there is evidence of progress in the manufacture of tools made by man, it cannot fail to be of interest to discover the exact nature of that evidence and, if possible, when it began and to what it has led. From the splinter of bone or piece of stone used in the hand to the diamond drill of to-day is an immense advance, but it can be traced step by step without a break. It is hoped that some new suggestions may be here offered tending to add to the present stock of information regarding some phases of aboriginal work.

Professor Mason suggested to the writer that much might be done to demonstrate the methods of aboriginal work, and all possible facilities were offered by him in the experiments which have been conducted at the United States National Museum during the last two months. The purpose of this paper is to explain some of these experiments. All the tools used were similar to those of the North American tribes, and all the objects produced were fashioned with these tools, which were made out of raw material. The principal work which has been done is the pecking of stone with the stone hammer and the carving, polishing, rubbing, and boring of stone with the rudest appliances. The result of the experiments goes far toward proving that the time required for the manufacture of stone implements by primitive man was very short. If the time occupied by the writer has been short, it is fair to conclude that a skillful workman, using the materials which long experience had taught him were the best for his purpose, would accomplish the task in much shorter time.

In a paper read before the Anthropological Society a year ago reference was chiefly confined to the literature in regard to the stone hammer and to the theories as to its use, only a single groove in a piece of porphyry having been attempted in illustration. In the present paper the experiments made will be fully explained and but slight reference made to anything previously written on the subject. The theories advanced in the former paper were generally accepted as correct, but some questions were raised as to whether the work could be performed as suggested.

The material of a grooved nephrite ax made by the writer is from New Zealand, and was procured through the kindness of Professor Clarke, of the United States National Museum. This stone is one of the toughest as well as of the hardest known, and when work was first commenced on it it was irregular in shape as when broken from the large bowlder, with sharp edges that cut the hand as the stone was struck with the hammer. In pecking with the stone hammer about one hundred and forty blows were given to the minute. The hammers first used were of quartzite from Piney branch, on the edge of Washington city. About forty pebbles were destroyed before one was found tough enough to stand the necessary pounding. With a single exception, none lasted more than ten minutes. The exception was a close-grained gray quartzite, with which was performed eight or ten hours' work.

Gabbro or black granite was then used for a hammer and was found useless; gneiss proved to be no better, and the work appeared hopeless. Finally, through the kindness of Mr. Weed, of the United States Geological Survey, a rough piece of compact yellow jasper from the Yosemite was obtained, with which about forty hours' work was done. The jasper was worn but slightly, the nephrite losing about the same weight as the jasper. This hammer is yet large enough to manufacture many dozens, if not hundreds, of such implements as the celts and axes usually found in this section of country. With a nephrite hammer of suitable shape, having a narrow periphery, the work of fashioning this ax could probably have been done in one-half the time.

In the process of manufacture, owing to a flaw, a large piece of the blade was broken off, and a second flaw, running diagonally through the specimen, threatened to destroy it if the hard pounding was continued. Work on it had therefore to be curtailed. The groove could not be worked deeper because the jasper hammer did not have a narrow edge. The outline having been carried as far as was thought safe, grinding on a block of rotten granite was resorted to; the granite was kept wet and the nephrite, being held in the hand, was rubbed backward and forward for about five hours. Subsequently it was polished with a pebble of compact quartzite, both dry and wet, the process occupying about six hours. The ax was then rubbed with wood and with buckskin to further polish it, but apparently without effect. The pecking occupied 55 hours and 10 minutes, which period, estimating the number of blows per minute as 140, would give over 460,000 blows required for the manufacture of the implement. This stone weighed when first received 7,625 troy grains; the present weight is 5,143 grains; the loss therefore is 2,482 grains. This specimen, however, can hardly be taken as a fair standard of aboriginal work, for in selecting the material a workman would naturally choose a pebble as nearly the desired shape as could be procured, and thus avoid a large part of the labor. The savage, if we can believe the accounts given of him by early travelers, was not likely to make unnecessary exertion.

In contrast to the obdurate nephrite, a block of kersantite was selected. This kersantite is from New Jersey, and is a much tougher stone than was generally used for the common stone ax or celt found in the eastern portion of the United States. The block was exceedingly rough when first taken in hand, yet it required less than two hours' labor with an ordinary quartzite hammer to produce a comparatively well-finished ax. A good idea of the time necessary to manufacture such an implement is thus afforded. The polishing was done with sand and water rubbed with a smooth piece of quartzite, the time required being included in the time specified.

A ceremonial object made of catlinite, manufactured by the writer, shows upon its surface very little pecking, although the rough block was shaped by the process just described. It would be difficult to say exactly how much time was occupied in shaping, boring, scraping, pecking, and in the attempted polishing of the object; nor would it be of interest, for subsequent experience shows that most of the work might have been saved. Some hours were wasted in scraping, as the work might have been done by pecking in half the time. The pecking was accomplished with sharp-pointed quartzite tools, but a hammer of suitable size would have reduced the time perceptibly. Much time was consumed in the necessary resharpening of tools. With the knowledge gained from the experiments made in the manufacture of this implement, which occupied about 16 hours in all, it could certainly be duplicated with proper tools in from six to eight hours. The following is a description of the process: Pecking was first resorted to, and when it was thought to have been carried as far as was safe various kinds of scrapers were used, the scraper being held between the thumb and forefinger. For this purpose quartzite, chalcedony, chert, jasper, and other spalls were used with equally good effect. The cramped position in which the spalls were held suggested that hafting would be an improvement, and, when tried, double the work was readily performed, that form of hafting being most effective which gave the greatest purchase. A nephrite celt was found to cut well, and the shape makes it a comfortable tool to hold in the hand. The striation left by the scrapers of quartzite strongly resembled file-marks, while the chert, having an edge perfectly smooth, left a mark that might be taken for the scraping of a steel blade. Scraping, however, did little toward reducing the size of the catlinite; so that pecking was substituted, although at the time it was thought to be attended with risk to the proposed implement. Along the line of cleavage catlinite fractures with a slight blow, while across the grain it was found to be very tough and to stand pecking well, even where not over one-quarter of an inch thick. This pecking was continued until the implement attained its intended form; then it was again scraped to obliterate the marks of the hammer. Next it was ground with coarse sandstone; then with a block of wood with sand; then with a coarse and then a fine quartzite pebble with water; then jade was used with water; next a walrus tusk was tried, and was effective in smoothing the surface; finally it was rubbed with buckskin. Much of this work could be omitted with advantage. Catlinite is said to be quite soft when first taken from the quarry, but subsequently becomes much harder. Serpentine is much harder than the catlinite, but may be pecked quite as readily and is not very difficult to bore.

An obsidian object, next manufactured, representing a human face, is interesting because it shows the method by which this brittle glass may be worked with any sharp-pointed hard tool by a succession of taps, which when given across the lines of cleavage cause spalls to fly off which can be regulated by the desire of the worker. A very light blow along the main line of cleavage will frequently break off large spalls. If the blow struck along this line is at a slight angle the danger is greatly lessened. An expert workman could, therefore, learn in a short time to avoid blows that would endanger the specimen. Quartzite and fine sand and water grind the rough surface away very readily, although a quartzite point with water alone acts almost as well.

A basalt glyph was fashioned from a block of stone brought from Arizona for the purpose, and when received had still a rough surface as when split from a large bowlder. The upper edge and two ends were weathered and soft for about one-half an inch. The figure represented was that of a toucan taken from a small engraving in Stevens' Yucatan, less than an inch square and enlarged. The glyph is about 12 × 14 inches. The surface of the stone was pecked into shape with an ordinary quartzite pebble hammer in about five hours, and appeared as though done with a steel bush-hammer. The grooves to be cut on this stone would not allow of the use of a stone hammer, so the necessary tool had to be improvised. Quartzite pebbles were chipped to a sharp point; these were held in the hand and quick blows were given upon the desired lines until the outline was well defined. The next task was to deepen the lines. This was done in the same manner, but in the work there was such an accumulation of detritus that it was found necessary to use a stiff brush to keep the face of the stone clear. In working with these quartzites a great difference in quality was observed—some would last three or four times as long as others, requiring constant resharpening. Had harder and heavier implements been available the work would have progressed much more rapidly. In stone-carving pointed tools are required where the spaces to be worked are narrow, size and weight depending on the available surface of the glyph. Where the surfaces are broad, water appears to expedite the work by softening the basalt.

Tools about the size and shape of candles, made of a hard stone, are in the Smithsonian collection from Mexico, and were probably used by the Mexicans in carving. The cutting on the glyph required about 12 hours, including the time required to sharpen and repoint the tools. To separate this slab from the original block by a saw run by steam took 12 hours and 30 minutes. The saw had 80 strokes to the minute, the stroke being ten inches.

A pipe was manufactured to show the probable method of working catlinite with stone, although the assertion has been made that no articles were wrought of this material prior to the advent of the whites in America. Dr. Charles Rau's work* describes the only experiments which have probably ever been made in this direction, and has been favorably quoted in most archeological works published since that time. He succeeded in boring a piece of diorite with a wooden shaft used with sand and water, employing the pump-drill. With reference to the epoch of this kind of work it may be said that Sir John Lubbock places the bored Thor hammer of Europe at the beginning of the bronze period, and other writers apparently agree with him, although the hammers have been found under circumstances that would indicate their manufacture at an earlier epoch. Schliemann found them in the lowest city of Troy, where but a trace of metal was discovered, associated with implements of stone capable of doing all the work necessary for their manufacture. It is hardly to be supposed that a people possessed of bows and arrows could have existed for a long period without discovering the use of the hand-drill, the bow-drill, and the pump-drill, and everything indicates that these tools were well known in the early periods of Asia and Africa. The Babylonian cylinders and Egyptian scarabæi, made of jasper, carnelian, and other extremely hard stones, with small holes drilled through them, show that drilling had been carried by these nations to a high degree of perfection. The Thor hammer, the bored objects from Central and South America, the ceremonial implements, pipes, tubes, and pearls of North America, all go to demonstrate that the art of boring was well known to races living in the pure age of stone. Some of these holes have been bored through stone twelve inches in thickness, and the same general character of work appears in all. Some holes were bored with solid shafts, others with hollow cylinders, the holes varying in diameter from less than one-sixteenth of an inch to more than an inch. Some holes show convexities at the bottom, some concavities; some show but little space between the core and sides of the hole, others a larger space; some of the cores are larger at the center of the hole than at the beginning. While some holes are bored from one side only, the rule appears to have been to bore from the opposite sides, often failing to meet accurately in the center. Some of the holes have been enlarged by cutting and scraping subsequently to the boring. The experiments made by me, while leaving much to be learned, demonstrate conclusively that the various processes may all be explained satisfactorily, and they present some new and interesting features. Every indication tends to strengthen the belief that the methods employed were simple and the work easily accomplished. The hand-, the bow-, and the pump-drill were used by different nations in fire-making. So soon as they had learned to make fire by boring they might have learned to bore almost any material likely to be met with if, indeed, the boring did not precede the fire-making. A hole might readily be bored in soft material with the hand-drill held perpendicularly and worked either with both hands or with one hand on the knee. The bow-drill can be used by holding the head-piece in the teeth, in the left hand, or against the breast, the first and last ways suggested leaving the left hand free to hold the object being worked. The pump-drills vary greatly in size, as do the bow-drills, and in boring were probably worked with one hand, although greater power could be obtained if the object were held firmly in place by some other means, thus leaving both hands free to operate the drill. In addition to these, there were probably other methods employed. A drill worked by string and whorl would have had greater motion, but the experiments have been carried only to a sufficient extent to demonstrate conclusively the effectiveness of the primitive drill in boring.

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* "Drilling in Stone without Metal," Smithsonian Report, 1868.

A block of catlinite with specimens of boring is not offered as exhaustive evidence by any means of the possibilities of different methods of boring, but it cannot fail to be of interest, showing as it does the commencement of holes made with the bow and pump drills. In starting the holes it was found that the pointed drill of stone or copper readily caught hold of the material, whereas the wooden or bone points hardly made any impression. In using hollow cylindrical drills it was found necessary to employ a guide to start the hole, either by using another hollow cylinder or, more simply, by pecking a slight depression to guide the point and prevent the drill from leaving the hole. Boring the catlinite with a brass cylinder and water was found to be impracticable, though with sand it would do well. While wood and bone would not catch hold of the stone when used alone, they are among the best materials for use if the hole is first started, and they are then used in connection with dry sand. The flanging point drill of solid copper with beveled edges cuts more rapidly than any other implement when used without sand. These holes, varying in depth from a faint depression to one-half inch, required from 20 seconds to 10 minutes to bore. In doing the work it was found that a flaring edge to the point would soon cause the drill to choke. The drills with parallel sides worked much longer, but were liable to break after a certain depth was attained, unless the drill-shafts were kept perpendicular to the object being bored. This accounts for and satisfactorily explains the boring of implements from two sides. Boring with a solid shaft from one side, by reason of the shaft bearing on the sides of the hole, would necessitate more labor than by boring from opposite sides. In boring with drills of wood or metal without sand, choking usually begins at a depth of one-half to three-fourths of an inch. With metal drills water obviates this to a certain extent, and sand helps very greatly, although the sand decreases the size of the core if a tube drill be used, for it cuts inside and at the base of the cylinder. If used without sand it cuts only at the base and naturally leaves but little space between the core and sides of the hole. The cores which are larger at the center than at the surface may be readily explained by the fact that the tube spreads from pressure and from the fact that the sand is retained within the hollow. But this is stated only as a theory, and remains for future experiment to demonstrate. The hole being once started with stone or metal, a drill-point of wood or bone and dry sand forms a very efficacious boring tool. In the early stages the solid drill will expel the sand rapidly, but does so less and less as the hole deepens. In working the pump-drill a jumping motion is easily attained, allowing the sand to drop back to the bottom of the hole, thus hastening the work. In boring with stone siliceous material, water and sand greatly advance the work. Working with the object under water and using sand, the water causes the finer particles to float off and enables the point to cut much faster. If water is used in connection with wood it softens it and causes the point to wear away rapidly without producing any useful result. Aboriginal implements with drilled holes in them are in a vast majority of instances made of comparatively soft stone, although there are some notable exceptions in jasper, a stone that cannot be readily penetrated by any of the methods above referred to unless corundum were used in place of sand, in which event any hole could readily be bored with a solid copper point.

One thing very necessary to good work with the drill is that the point should be perpendicular to the shaft and firmly attached, as the slightest motion to the point causes much additional labor by increasing the diameter of the hole and giving a disagreeable motion to the drill, in addition to endangering the safety of the point. In my experiments the points were attached with wet rawhide, which after drying formed very firm bands. The object to be drilled naturally governs the method employed. The aboriginal stone-drill points are usually of a very compact jasper or quartzite, other stones breaking quickly, and in drilling hard stone a constant resharpening of the points is necessary. The more obdurate the material of the tool, the less the labor required to keep it in order.

The first experiment in drilling was in a piece of limestone, which was performed in a few minutes with a bow-drill and stone point. A small "banner stone," an inch and a half thick, was of a siliceous material of an irregular shape. The boring was done from both sides with a pump-drill and a jasper point. Chopping on one side, the stone was turned over and the work finished from the other side, requiring about three hours' labor. A hole in siliceous sandstone about one and one-fourth inches in thickness required two hours to bore with jasper point and drill. It was first essayed with the jasper alone, but the point wore smooth and required constant resharpening. Dry sand with the jasper cut well, but constant cleaning of the dust formed by the sand was necessary. The stone was then covered with sand and enough water poured on to float off the fine particles, and by imparting a jumping motion to the drill, fresh sand took the place of that which had been pulverized and the cutting progressed more rapidly and the wear on the drill-point was less than by either of the other processes. Serpentine was drilled successfully with jasper, both dry and with water.

Catlinite is about as hard as banded slate, from which ceremonial implements were commonly made. A hole in catlinite five inches deep was drilled in about three hours with a pump-drill. A jasper point was first used, but it began to choke when the hole was one-half or three-fourths of an inch deep. A pine drill was then used with dry sand, but the point wore away very fast. The addition of water made matters worse, for it softened the wood, and the dust from the catlinite formed a putty-like mass, which choked the drill. A shaft of ash being substituted for the pine, and dry sand being used instead of wet, the drill ran smoothly, and by giving a slight jumping motion to the shaft a great deal of dust was expelled with the sand, and work progressed satisfactorily. A proper drill of copper would have cut the same hole possibly in an hour; one of jasper with sand would do the work probably in two hours.

In the Smithsonian Institution are some small objects of red jasper from Mississippi, having in one or both ends holes not over one-sixteenth of an inch in diameter and of about the same depth; also some bored shells with holes about one-eighth of an inch in diameter and as much as six or more inches deep, piercing the shells. Experiments to bore jasper and shell similar to the above have been so far unsuccessful. Upon the jasper the three drills have been used with all kinds of available points, including quartz, nephrite, and copper; even hard steel drills were tried, and were equally unsuccessful, nothing penetrating these obdurate specimens. A copper point on a pump-drill used with emery, however, started the work and would in time have completed it. A small drill of jasper used with emery might have answered. Corundum mines exist in North Carolina and possibly nearer to the localities from which these articles were brought. The Indians are known to have possessed emery early in the seventeenth century.

A piece of catlinite fashioned into a rude pipe exemplifies the methods of boring and pecking. Two holes made by me in a slab of marble represent about 15 minutes' work each, one side being bored with a pump-drill having a three-foot shaft an inch in diameter, with a five-pound whorl and tipped with a cylinder of manufactured copper. It was used without sand or water, a slight depression being first pecked on the surface to keep the cylinder in place, and the pump was worked with both hands. The opposite side was worked with the same drill with a wooden point and dry sand. Pieces of slate were drilled in both ways by hand-drills, by bow- and pump-drills. With the two latter drills quarter-inch holes can be bored with stone points in two or three minutes.

Experiments were made in sawing stone, but they have not proceeded far enough to be spoken of with any degree of certainty. Slate was readily sawed to the depth of an eight of an inch with stone blades used alone, in a few minutes. Nephrite was sawed with a sheet of native copper, sand, and water; quartzite was sawed with roofing slate, sand, and water, requiring but little time. Bone and rawhide were also tried, both with and without sand, but proved ineffectual. In sawing stone it is necessary, of course, that the saw be of a harder substance than the object to be sawed. In cutting soft stones, a commencement having been once made, it is easy to complete the operation by using as a saw bone, hard wood, or any other substance with either dry or wet sand. In the experiments made in sawing jadite from the Yukon great difficulty was experienced in making satisfactory progress with any accessible material, for while jasper, chert, and metals would cut the jadite, the work progressed slowly. By using wet sand in conjunction with these substances work was greatly facilitated; jadite, both with and without sand and water, formed, however, the most efficacious tool, cutting a groove one-fourth of an inch deep in about an hour. The examination of jadite articles from Alaska shows grooves and striæ similar to those produced by work with jadite on jadite.

A copper plate was made by me of a nugget about two inches long, an inch broad, and three-eighths of an inch thick at its thickest part; the copper was from the Lake Superior region. After partially flattening the nugget with the stone hand-hammer upon a pebble, it was found that the work progressed slowly because no stones of sufficient weight to perform the work rapidly were at hand. A steel hammer and anvil were resorted to until the plate was brought to nearly the desired size, when the light stone hammer and stone anvil were again used for about 20 minutes, and the specimen further flattened from one-half to one-fourth of an inch. Plate-like objects of copper were noticed in the possession of Indians by many of the early travelers.

EXPLORATION OF THE ORINOCO.—Our topographic knowledge of the Orinoco basin and that of its affluent, the Caura, has been greatly advanced by the explorations of the intrepid J. Chaffanjon, who visited these parts at the expense of the French ministry of public education. His order is dated from May 24, 1884, but the expedition was carried out in 1886 and 1887, and published in Paris, Hachette & Co., 1889, in a duodecimo illustrated volume entitled "*J. Chaffanjon, L'Orénoque et le Caura.*" The report is composed in a fluent style, and reads like a novel; indeed, here we may say that truth is sometimes stranger than fiction. The contests with the barbaric Indians, whose customs Chaffanjon describes minutely, were severe enough—he was repeatedly robbed and deprived of his provisions, garments, merchandise, and boats, and often nearly despaired of the accomplishment of his journey. About the worst pests that befell him were the musquitos and the niguas or jiggers, of which insects all tropical travelers speak. The Indian tribes described by him number over fifty and mainly belong to the Maipure family. They appear to be much less changed or disintegrated by European civilization than the North American aborigines. The ample information contained in this book should be secured by every student of South American countries and Indians. There are *eight* vocabularies of considerable length at the end of the volume (pp. 319–351).

A. S. GATSCHET.

DEATH OF GENERAL MARIANO JIMÉNEZ.—The death of General Mariano Jiménez, constitutional governor of the state of Michoacan de Ocampo, on February 28 is announced. General Jiménez was the founder and patron of the museums of Oaxaca and Michoacan, and had devoted much wealth and labor to Mexican archeology, particularly to that of Zapoteca and Tarasca.